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FLUME SYSTEMS for Handling Bulk-Stored POTATOES

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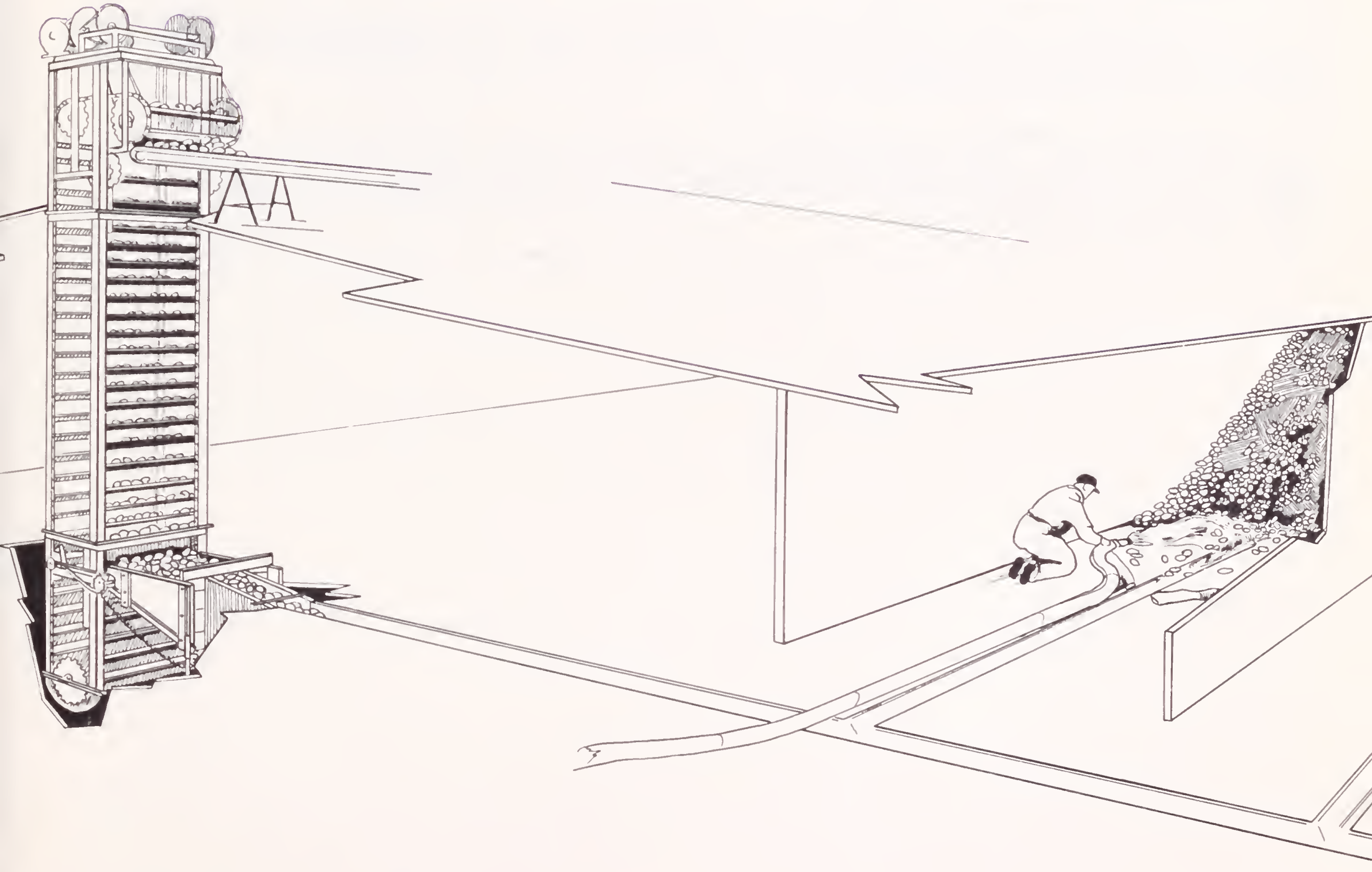

UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Marketing Service
Marketing Research Division Washington, D.C.

Marketing Research Report No.177

PREFACE

This report, based on research at the Red River Valley Potato Research Center, East Grand Forks, Minn., is part of a project to develop more efficient work methods for off-farm handling of late-crop potatoes. This research is conducted under the general supervision of Joseph F. Herrick, Jr., Transportation and Facilities Branch, and J. M. Lutz, Biological Sciences Branch, Marketing Research Division. This is an interim report on one phase of the long-range research projects of the Agricultural Marketing Service.

The authors express their appreciation to the potato warehousemen in whose structures observations were made and to the agricultural experiment stations of Minnesota and North Dakota and the Red River Valley Potato Growers association for their cooperation in the recent work.

Credit is due Wallace Ashby, head, Farm Building Section, Agricultural Engineering Research Division, Agricultural Research Service, under whose direction this work was initiated and partially completed.

The authors gratefully acknowledge the cooperation and assistance of A. H. Glaves and Albert Dubuque, Agricultural Engineering Research Division, Agricultural Research Service, for early flume testing and design work with sheet metal at the Research Center, East Grand Forks, Minn.

June 1957

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SUMMARY

Since 1940 there has been a shift away from grading of unwashed potatoes to washing the potatoes before packaging. This shift has made possible the use of flumes for moving potatoes from bulk-storage bins to the washing and packing lines.

Potato fluming, which probably originated in a plant in Torrington, Wyo., is the moving of potatoes from one point to another by means of water flowing through a sluice or flume connecting the two points. Flume systems are so designed that the desired volume of potatoes and water can be put into the flume at the receiving end, and the potatoes taken out and the water disposed of on the discharge end. In most systems the water is recovered and recirculated.

The flume is filled by piping the water (1) into the back of the bin and letting the potatoes fall into the flume or (2) into the front of the bin and using a canvas hose to wash the potatoes into the flume. The length of time the potatoes are in the water depends on the distance they are flumed; the soaking they receive during this time loosens the soil and helps the washing operation.

Test runs were made to check the effect on quality. When proper fluming velocity was used, only about 8 percent of the potatoes received any injuries, and none of these was serious enough to exclude the potatoes from U. S. Fancy Grade. Injuries received in other tests showed that high velocities (over 120 feet per minute) should never be used.

Flumes should be large enough so that large potatoes do not wedge crosswise and clog the flume and small enough so that the volume of water needed is not excessive. The flume should also be designed: (1) To keep the velocity of the potatoes below 60 feet per minute and (2) to keep the potatoes in the flume from 6 to 8 minutes where possible.

The use of flumes to move potatoes from bulk bins to the washing and packing line (1) requires less labor than other methods, (2) makes washing equipment more effective by loosening the soil, (3) handles the potatoes with less injury than other methods, and (4) for long-distances, costs less for ownership and operation than conveyors.

Labor savings can really be significant. One plant has installed flumes to replace a conveyor system and now uses 1 worker to direct the flow of water to move potatoes into the flume; formerly, a crew of 4 to 6 workers was needed to fork the potatoes into the conveyors. Fluming also eliminates the need for cleaning up the soil left in the bins, because during fluming operations all the soil is washed out through the flume system.

FLUME SYSTEMS FOR HANDLING BULK-STORED POTATOES

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and
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BACKGROUND OF THE STUDY

Before 1940 practically all of the commercial late-crop potatoes were graded and packaged without washing. Now, many late-crop areas report that 80 percent of the potatoes marketed are washed before being moved into commercial channels. In potato packing plants where potatoes are not washed, small portable graders are moved to the storage bins. Here the potatoes are fed into the grading equipment by hand-forking them into a hopper and short conveyors. With more packing plants washing potatoes, a shift has been made to large stationary washing and packing lines, and this shift has increased the output per line. Where portable graders are used, a crew of 6 to 8 workers grade about 1 carload of potatoes a day per grader; where large stationary washing and packing lines are used, crews of 8 to 30 workers pack 2 to 8 carloads per line.

Many early washing and packing lines were fed by moving potatoes from bins to the line in containers or on bulk conveyors. For example, a plant in Torrington, Wyo., which is credited with being the first to use the flume for moving potatoes, used a series of belt conveyors to feed the washing line. In 1942, this plant tried a fluming installation of the type used for sugar beets. This installation used a wide rectangular flume and circulated about 800 gallons of water a minute. Since then narrower flumes of trapezoidal cross section, using about half as much water, have been developed for potato fluming. Fluming is now generally used in plants in which a minimum of 10,000 bushels of potatoes is to be moved an average of 50 feet or more to a washing and packing line.

WHAT IS POTATO FLUMING?

Potato fluming is the conveying of potatoes from one point to another by means of water flowing through a sluice or flume that connects the two points. The flume system must be so designed that the desired quantities of water and potatoes can be put into the flume at the receiving end, and the potatoes taken out and the water disposed of at the other end. The water can be discharged into a sump and recirculated. Or, where unlimited supplies of water are available, the water can be discharged into a settling field or stream. The general practice is to discharge potatoes and water into a space in which the potatoes can be held and the water, loose soil, and trash drained into a sump. In the sump the soil and trash settle, and the water can be recirculated by a pump. The potatoes are conveyed or elevated from the end of the flume to the washing and packing line.

The slope and section of the flume must be such that there is neither undue settling of soil and clogging by potatoes nor high velocity to injure the potatoes. The bottom and sides of concrete flumes should be as smooth as possible.

FLUME PERFORMANCE

Moving Potatoes into the Flume

In the oldest and most commonly used method of moving potatoes into the flume at the bin, the water enters the flume at the rear of the bin and flows under plank covers, which keep the potatoes out of the flume. These covers are removed a plank at a time from the front of the bin, allowing potatoes near the open flume to roll into the water. Potatoes at the sides of the bin are hand-forked into the flume. To prevent occasional avalanches from temporarily blocking the flume, some of the plank covers are replaced, as the potato pile recedes, so that only a foot or so of the flume is left open. Because of the labor required to fork potatoes into the flume, this method of feeding the flume is not as good as a newer method now becoming more important.

In the new method of feeding potatoes into the flume, a pump forces the water through a large pipe from the sump to the front of the bin. A large hose, attached to the pipe, is used to direct the flow of water into the bin. As with the other method, the flume in the floor of the bin is covered with short planks, which are removed one at a time as the face of the potato pile moves deeper into the bin. With this method, it is not necessary to replace the planks. As the plank covers are removed, the flume water is directed against the pile of potatoes so that they are washed or flushed into the flume (fig. 1). Long canvas bags filled with sand can be used as dikes so that the water from the hose will not spread over the bin floor. One advantage of this method of feeding the flume is that no hand forking is necessary, and injury from forking is eliminated. Another advantage is that feeding is regulated by directing the flow of water toward the pile or away from it.

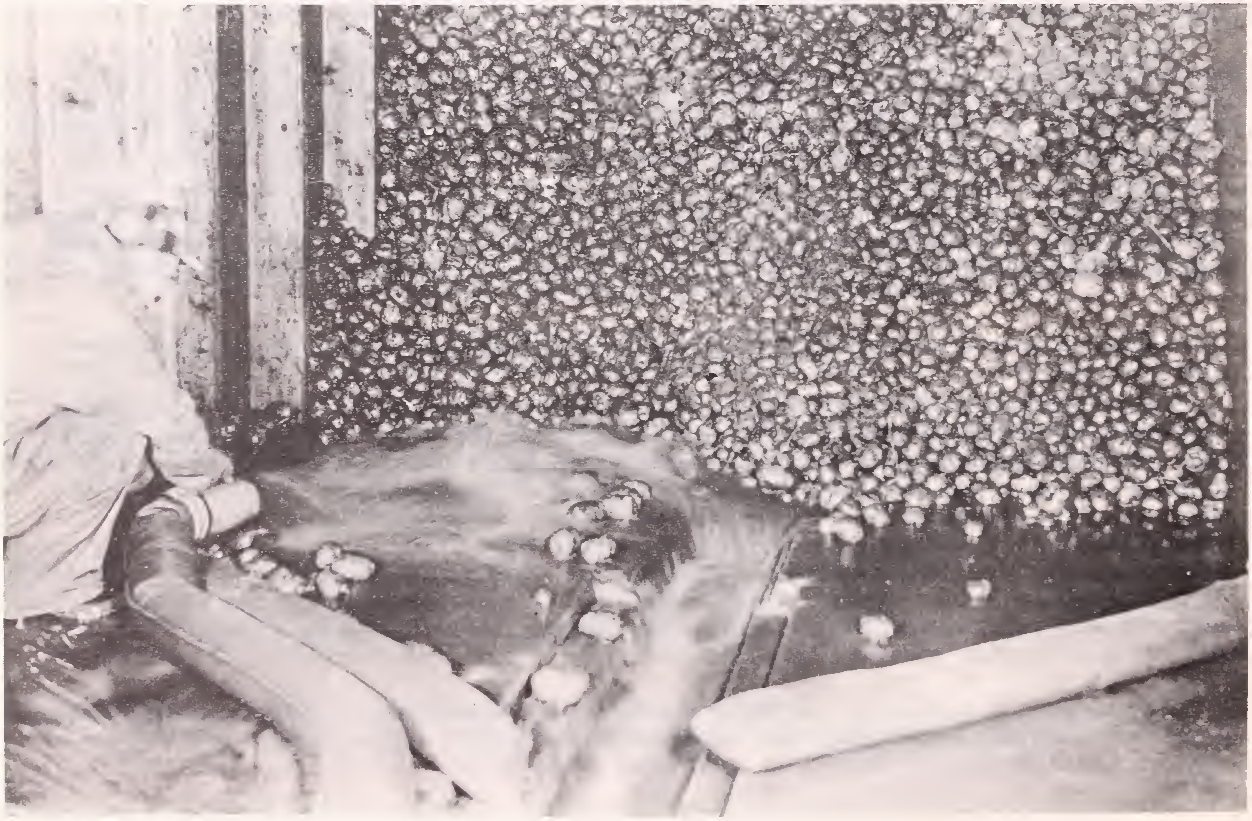

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Figure 1. --Washing potatoes into the bin flume with 300 g. p. m. of water delivered through a 4-inch aluminum pipe and a 6-inch canvas hose. Note sand-filled canvas floor dikes used to force runoff of water into the flume.

Conveying Potatoes From Bin to Packing Line

During fluming the water tends to soften and loosen the soil on the potatoes.[1] This effect varies with the nature of the soil and the period of time the potatoes are in the water. The length of time the potatoes are in the flume varies with the distance they travel and with the practice followed in operating the flume. For example, with a given amount of water the flume can be run nearly empty or practically full, depending upon whether or not the flume is restricted at the lower end.

Table 1 lists variations in the operation of a flume 100 feet long, using the same amount of water, a small range in the feeding rate, and a wide range in the holding period. In runs 5 and 6, potatoes are soaked in the flume long enough to wash most of the soil off. In run 1, time in the flume is so short that the soaking is not very effective in softening the soil, and at the same time, velocity of the potatoes is great enough to bruise some of them.

Table 1.--Performance characteristics of water and potatoes in a 100-foot flume with 300 gallons of water per minute and with the outflow of potatoes and water regulated at the end of the flume, 6 different runs

Run No.	Water			Potatoes			
	Depth in flume	Quantity per ft. of flume length	Velocity per minute in flume	Velocity per minute in flume	Quantity fed into flume per minute	Time in flume	Quantity held back in flume
	Inches	*Gallons*	*Feet*	*Feet*	*Pounds*	*Minutes*	*Pounds*
1....	5	2.32	138	120	160	0.83	133
2....	10	5.25	61	33	180	3.00	525
3....	11	5.85	55	28	170	3.67	610
4....	12	6.47	49	23	170	4.40	732
5....	12	6.47	49	14	200	7.20	1,460
6....	13	7.10	45	15	140	6.67	930

Fluming is practical for conveying potatoes at greatly varying rates--1 to 8 carload equivalents per day, or 5,000 to 50,000 pounds per hour. Distances potatoes travel may range from 10 to 800 feet. Test runs in table 1 are based on a distance of 100 feet, but in the storage at the Research Center, fluming distances range from 15 feet to 150 feet. At the Center the packing rate is 2 carload equivalents per day, or about 10,000 pounds per hour. In many of the commercial storage and packing houses in the Red River Valley of Minnesota and North Dakota, flumes are used to move 6 to 8 carload equivalents of potatoes to the packing line per day. This is a rate of 30,000 to 40,000 pounds per hour.

Regulating the flow of potatoes from the flume, so as to insure uniform delivery to the packing line, is essential for an efficient fluming system. As may be noted in table 1, in runs 2 to 6 enough potatoes were held back in the flume to feed, for about 3 to 9 minutes, a packing line using 10,000 pounds per hour. A draper chain feeder can be used to move the potatoes onto an elevator (fig. 2). The feeder will deliver potatoes just as fast as the elevator can handle them; the excess potatoes back up in the flume.

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[1] Lutz, J. M., Findlen, H., and Hansen, J. Efficiency of Various Methods of Washing Red River Valley Potatoes. Amer. Potato Jour. 32: 340-345. 1955.

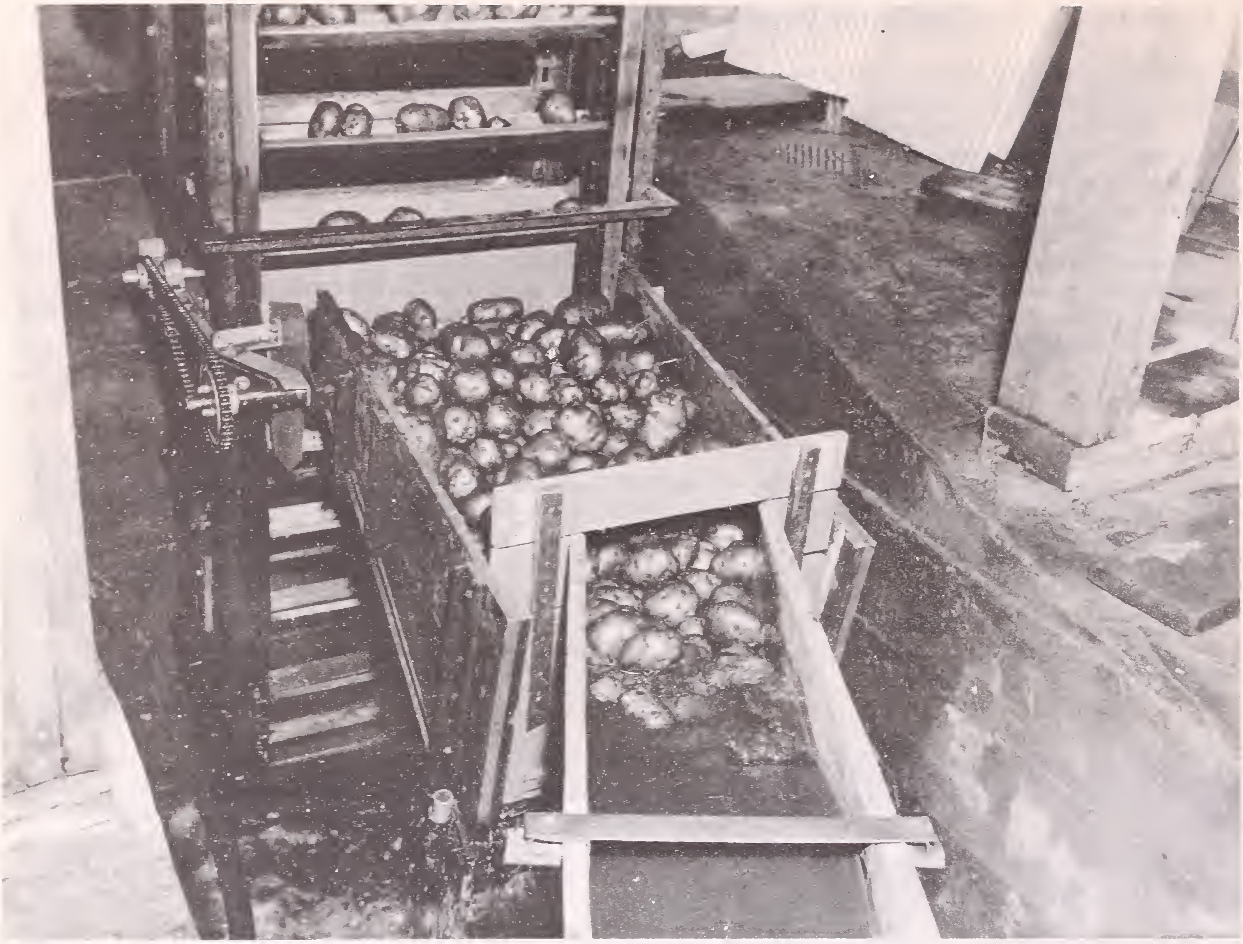

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Figure 2. --Draper chain feeder is geared to deliver potatoes just as fast as elevator can handle them, and excess potatoes back up in flume.

Removing Soil and Trash

Trash and soil can be removed from the bin and moved to the disposal field or the public sewer by the fluming system. At the Research Center, when bins were emptied by portable conveyors, 500 man-hours were required to handle soil and to clean bins after removing potatoes from the 30,000-bushel storage. Now, with the flume system, all soil is washed from the bins into fluming water, and accumulated sludge is pumped to a disposal field. This involves no cleanup time and saves the 500 man-hours.

EFFECT OF FLUMING ON POTATO QUALITY

During test runs at normal potato velocities of 15 to 30 f.p.m., 1,000 pounds of Irish Cobbler potatoes, free from injury, were put into the flume with a regular run of Red Pontiac potatoes. The test potatoes had been held in commercial storage at approximately 40° F. and 70 percent relative humidity for about 7 months. The white potatoes were put into the flume with the red ones, 5 pounds at a time. After the potatoes had traveled 100 feet in the flume and had been deposited on a draper chain feeder, the white potatoes were recovered from among the red ones. These test potatoes were then stored for 24 hours at about 50° F. and 30 percent relative humidity before being examined individually to determine the extent of injury. This examination revealed that 8 percent of the potatoes had small injuries, but none was serious enough to exclude the potatoes from U. S. Fancy Grade. However, when potatoes were moved in test runs at 120 f. p. m., 87 percent had small injuries, indicating that such velocities should not be used.

DESIGN AND CONSTRUCTION OF FLUME

Good flume design is the result of a series of compromises: (1) The flume should be large enough so that an occasional 6- or 8- inch potato does not wedge crosswise and clog the flume but small enough to handle usual volumes of potatoes with 300 to 600 g. p. m. of water; (2) the flume should be so designed that potatoes move less than 60 f. p. m., but the slope should be such that soil water velocities of 150 f. p. m., or more, are possible for cleanout runs; and (3) if possible, it should be designed to hold potatoes in water for 6 to 8 minutes to soften soil, but it should supply a uniform flow of potatoes to the packing line, even with alternate stoppage and overloading at the bin.

Flume Cross Section

The flume most commonly used is of early design (fig. 3). It is 14 inches wide at the top and 14 inches deep and has a 4-inch bottom radius. Figure 4 illustrates a more practical flume that is only 8 inches deep in the bin. Experience shows that 8 inches is deep enough, and the deepening beyond 8 inches is necessary merely to maintain bottom slope. If the floor slopes along the path of the flume, it is possible to keep the depth of the flume uniform. A flat bottom is preferable to a curved bottom.

Generally, flumes are cast in concrete floors, although some metal and wood flumes are used.

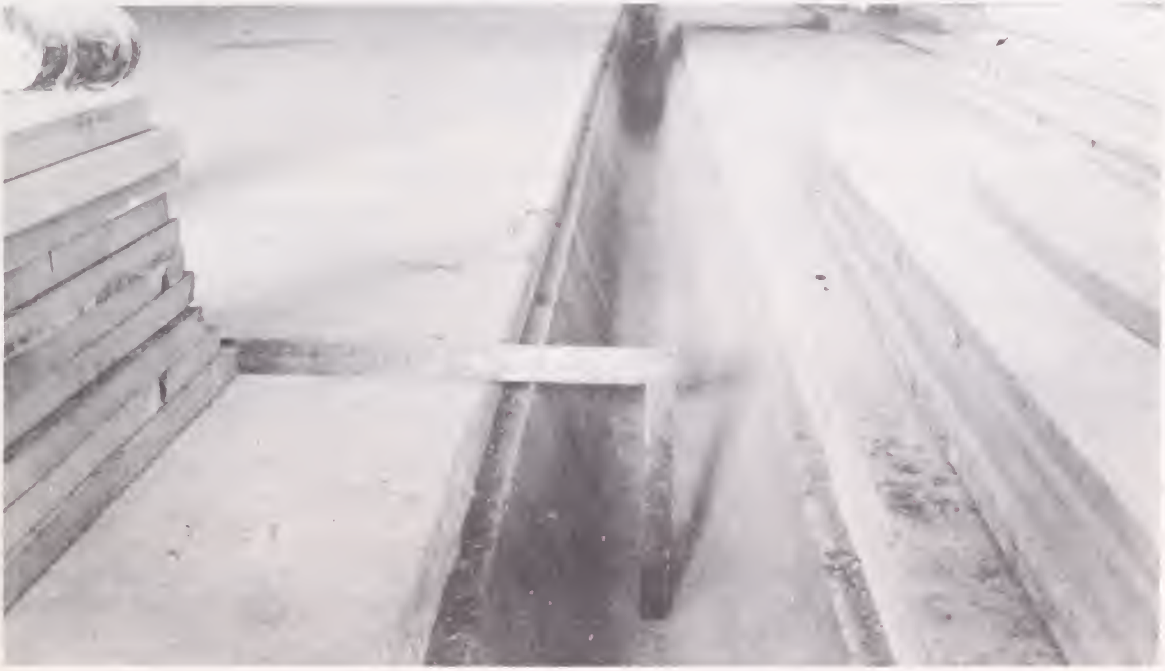

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Figure 3. --Early type of potato flume, widely copied in the Red River Valley. It is 14 inches wide, 14 inches deep, and has a 4-inch bottom radius.

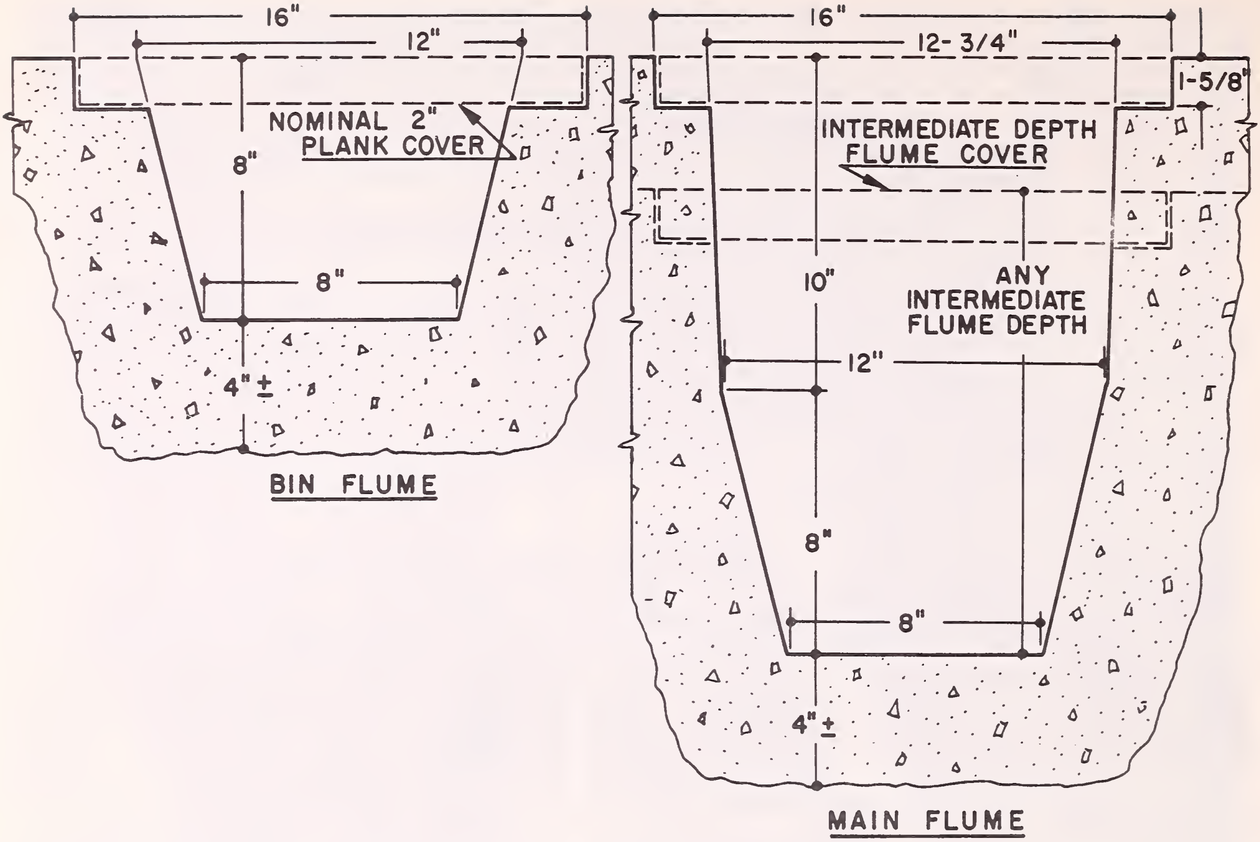

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Figure 4. --Flume design recommended for bin flumes and main flumes. (Note that depth of main flume increases because of required slope and drops at turns. All flume covers are the same length.)

Slope of Floor and Flume

Uniformity in slope of floor and flume, as well as in shape of flume, is necessary for adequate potato movement and minimum water flow. When the floor slopes toward the flume, potatoes may be easily flushed into the flume without having the water spread to adjoining bins and alleyways.

Flumes are designed for soil-scouring velocities of 150 feet per minute (f. p. m.) or higher. Such velocities should be used only during cleanout runs when no potatoes are being carried. Although flume slopes of from 1:120 to 1:240 (1 inch drop to 120 or 240 inches of flume) have been used, the potato and water level remains most nearly constant with a bottom slope of 1:180. On very long runs flume slopes may be limited to 1:216 because of existing floor levels; but in short runs, slopes of 1:144 result in better soil scouring (table 2).

Varying quantities of potatoes in the main flume and of water backed up into the bin or the lateral flumes will change the depth to which the flume is filled. Table 2 shows the relation of flume slope to velocity of water and capacity of flume. Any blocking at discharge end, or at turns, naturally slows the flow. Flumes should be deepened near the outlet so that when potato velocities are kept below 60 f. p. m. and potatoes and water back up during runs, there will be little overflow of water. Blocking at turns can be avoided by making the main flume somewhat lower than the lateral flumes to accelerate the water at the turns (fig. 5). In buildings with level floors, the main flume may have to

Table 2.--Velocity of water and capacity of flumes of different slopes when filled to various depths

Water depth	Slope of flume					
	1:144		1:180		1:216	
	Velocity of water per minute	Quantity of water per minute	Velocity of water per minute	Quantity of water per minute	Velocity of water per minute	Quantity of water per minute
	Feet	*Gallons*	*Feet*	*Gallons*	*Feet*	*Gallons*
4 inches.......	187	344	161	295	154	284
6 inches.......	226	659	202	588	184	536
8 inches.......	251	1,020	228	926	205	832
10 inches.......	237	1,430	246	1,290	222	1,160

be deepened to 2 or 3 feet in long runs to maintain the slope. This depth of flume may result in a considerable drop from the branch flumes to the main flume. Injury from such a drop can be reduced by installing sponge rubber pads opposite the branch flume being used.

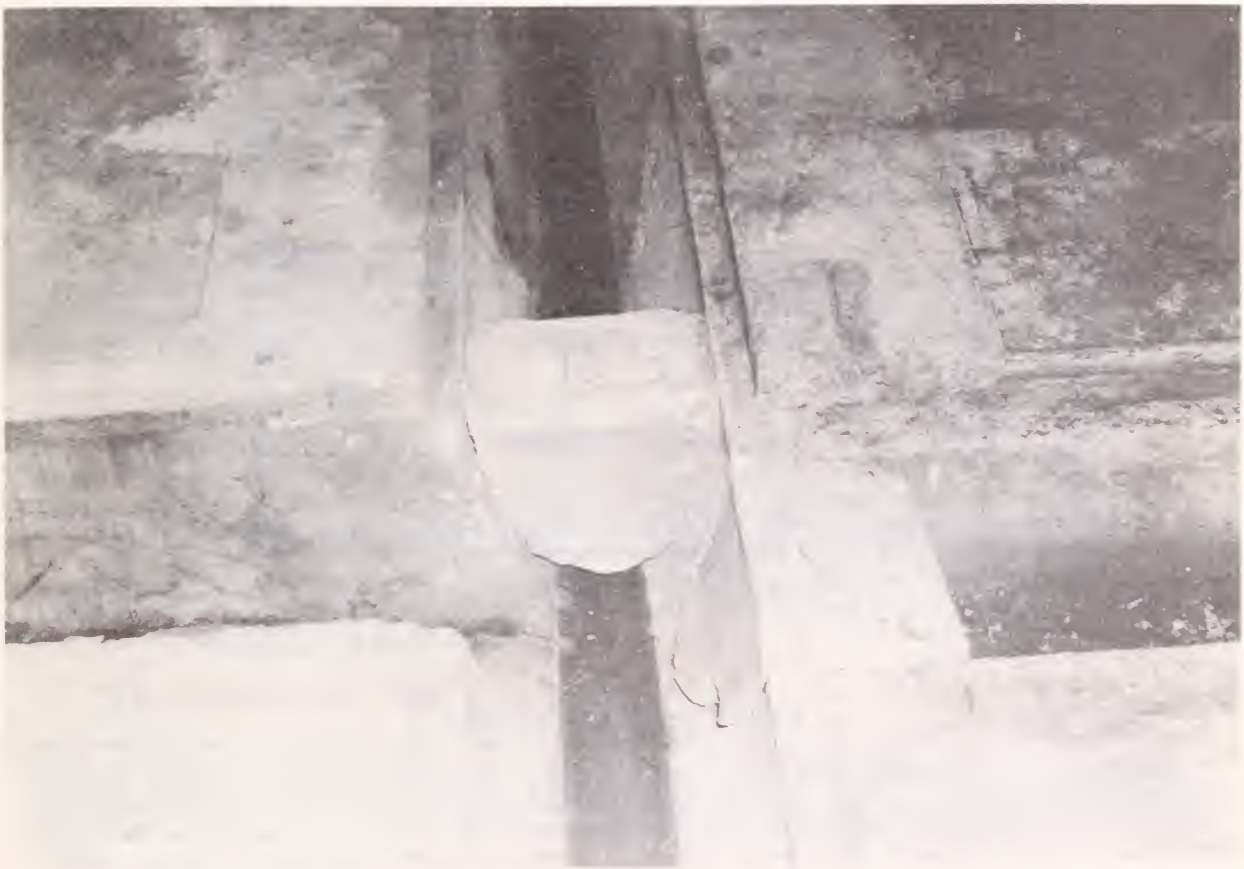

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Figure 5. --Branch flumes should have at least a 1-inch drop to accelerate water and potatoes around a turn. (Removable concrete dams, 5 inches thick, keep potatoes from backing into unused main or branch flumes).

Layout

Existing floor slope, footings, and partitions must be considered when flumes are installed in old storages. Usually, bins have level floors so the depth of the flumes must change to provide the necessary slope. In the early flumes, depths of 8 inches at the back of the bin and 14 inches at the front were common. This slope is adequate for conveying potatoes 100 feet.

A layout including main and lateral flumes is shown in figure 6. Elevations of floor and bottom of flume, above bottom of flume at outlet to sump, are indicated at 30-foot intervals. This system requires care in preparing the layout. All of the flumes in this layout are 10 to 12 inches deep. A series of valves can be used to direct the flow of water; however, some operators prefer to cap the pipes not being used to avoid the cost of these valves. With this system, many of the potatoes must be hand-forked into flumes from the sides of the bins.

An improved flume layout is shown in figure 7. This system is easier to lay out, cheaper to construct, and less expensive to operate. It incorporates drops of 1 inch or more in all turns, uses flat-bottomed bin flumes 8 inches deep, permits a level work alley, and uses portable quick-connecting pipe and hose to bring water to the front of the pile in the bin so that all potatoes and dirt can be washed into the flume. With the flume slope 1:180, dirt that settles to the bottom during "backups," caused by regulating the flow of potatoes, can be scoured out quickly between potato runs. Construction costs of this improved flume layout are less than the costs of the one shown in figure 6.

Dams and Floor Dikes

Water used in fluming from one bin will often back up into the flumes of other bins. This backup is objectionable if it carries potatoes into adjoining bin flumes, where they may remain for months. Removable concrete dams 5 inches thick will keep potatoes from backing up into the unused flume system (fig. 5).

The most effective way to direct water and potatoes into the flume is the sandbag dike referred to earlier. The dike, a canvas bag loosely filled with sand, is 6 inches in diameter and 4 to 6 feet long. Two to four of these dikes confine water to the area in front of the pile of potatoes and permit easy flushing of potatoes into the flume, even where the floor is level.

WATER SUPPLY, CIRCULATION EQUIPMENT, AND SLUDGE DISPOSAL

Water is used to carry potatoes from bin to elevator of packing-line conveyor and to carry sludge from the building. The usual practice is to recover the relatively clean water from the washer and add it to the recirculated water in the flume system. The heaviest sludge from the circulating water settles to the bottom of the sump and flume. The sludge is flushed out of the flume between potato runs and pumped out of the building into a sewer or settling field.

Pumps and Piping Needed

Sewage or trash-type pumps capable of pumping 300 to 600 g. p. m. are required in a potato fluming system. In most fluming installations a 4-inch pump will deliver this 300 to 600 g. p. m. of water against the usual friction and static head of about 20 feet of water. Table 3 has been prepared from data on 4-inch trash and sump pumps of 2 commercial pump manufacturers. This table shows the power required to pump 200 to 600 g. p. m. against head pressures of 10 to 80 feet. The list price of a 4-inch pump and motor ranges from $600 to $775, depending on the size of motor used.

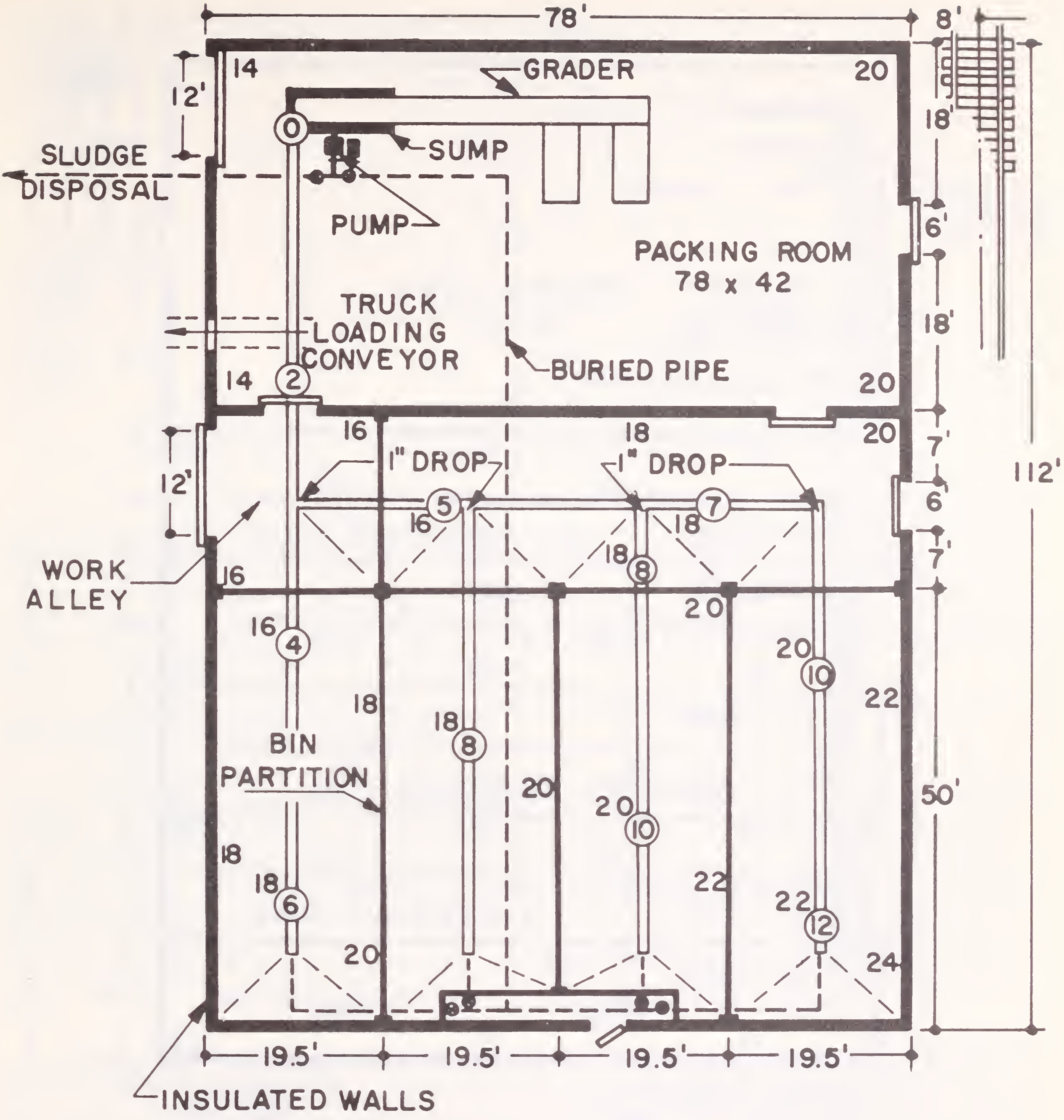

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Figure 6. --Flume layout with four 9,000-bushel bins, one 10,600-bushel bin, and corner work alley. Elevations of flume bottom (circled numbers) and floor (uncircled numbers) are shown at 30-foot intervals and are measured in inches above the flume bottom at outlet to sump. The floor slopes to the flume in the packing room, and slopes to and with the bin flumes in the storage area. Each bin flume is of constant depth--three are 10 inches deep, one 11 inches deep, and one 12 inches deep to provide for a drop of 1 inch at each turn. Buried pipe carries water from pump to bins, where it is valved into the flume at the rear of the bin being emptied. Some forking is required.

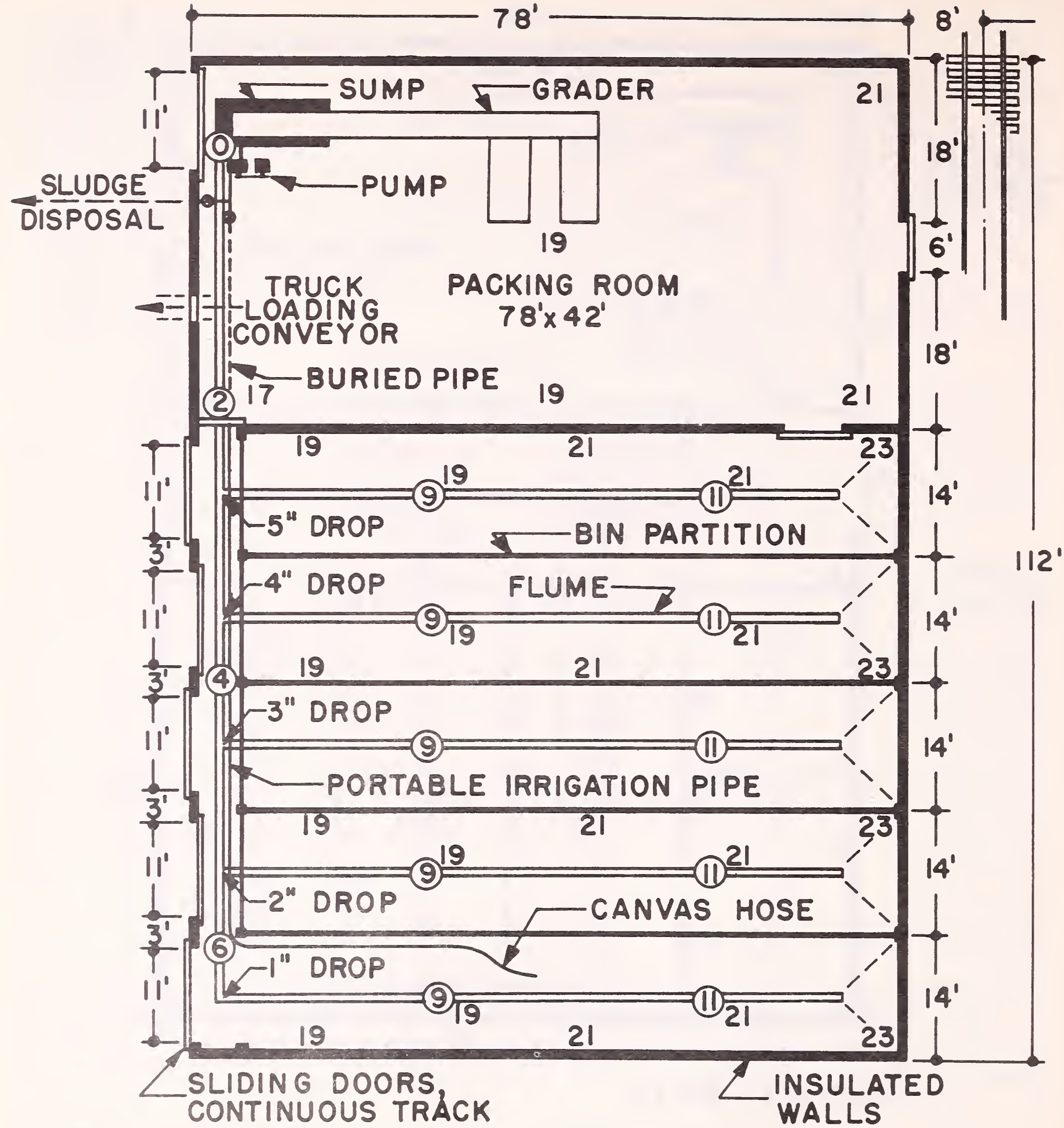

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Figure 7. --Flume layout with five 9,000-bushel bins. Elevations of flume bottom (circled numbers) and floor (uncircled numbers) are shown at 30-foot intervals and are measured in inches above the flume bottom at outlet to sump. Corresponding elevations are the same in each of the 5 bins where the floor slopes to and with the flume. Bin flumes drop 1 inch to 5 inches into the main flume. Portable irrigation pipe carries water to a canvas hose to wash potatoes from the front of the pile into the flume.

TABLE 3.--Power requirements related to size, capacity, and head pressure of sewage and trash-type pumps[1]

Pump size	Pump capacity	Power requirements when static and friction head is:					
		10 ft.	20 ft.	30 ft.	40 ft.	60 ft.	80 ft.
	G.p.m.	*Hp.*	*Hp.*	*Hp.*	*Hp.*	*Hp.*	*Hp.*
3 inches..........	200	1	2	3	5	7.5	10
4 inches..........	200	1	2	3	5	7.5	10
4 inches..........	300	2	3	5	7.5	10.0	12.5
4 inches..........	400	2	5	5	7.5	10.0	15.0
4 inches..........	500	3	5	7.5	10.0	15.0	20.0
4 inches..........	600	5	7.5	10.0	15.0	20.0	25.0
5 inches..........	600	3	5.0	7.5	10.0	15.0	20.0

[1] Motors should be 220 volt, three phase, and splash proof.

The pump should be installed at the sump with the intake covered with a grating or a screen to keep floating trash from damaging the pump. The grating or screen should be so designed that trash can be easily removed without shutting down the pump, removing the suction line, or pumping out the sump. A cage built of steel rods surrounding the suction pipe meets these requirements. Rods are spaced 1 inch apart and will not permit material to pass that would clog or damage the pump. This cage functions at all water levels, and trash can be removed with a garden rake. A grating that can be easily cleaned also protects the overflow from being clogged.

In one system, galvanized iron pipe, installed under the floor, carries water to the back of the bin and into the flume (fig. 6).

In another system, irrigation pipe with quick coupling connections is used to bring water to the front of the pile for washing potatoes into the flume. This layout is illustrated in figure 7. A canvas hose 6 inches to 8 inches in diameter is attached to the end of the pipe; this hose provides a large volume of low-pressure water to wash potatoes loose from the foot of the pile and into the flume. Most of the piping for a flume installation of this type should be 4 inches in diameter, although pipe 5 or 6 inches in diameter may be used for long distances to save power. Table 4 shows the friction head against which the pump works in forcing water an average of 200 feet through pipes of different diameters and through three 90° turns and one gate valve. The static head between sump intake and floor is added to the friction head to determine total head against which the pump must work.

Conditions at the Red River Valley Research Center were used to appraise the factors necessary in determining the sizes of pump and pipe to use. Table 5 shows the effect on head, motor size, and power requirements when from 3- to 6-inch pipe is used to deliver 300 gallons of water per minute through a maximum of 150 feet of pipe. Table 6 evaluates the costs of ownership and operation for the motor, pump, aluminum pipe, and fittings for the flume system used in developing table 5. Based on these cost computations, a system using 5-inch pipe would be selected.

At the Research Center 4-inch pipe was selected because of a local price advantage for the 4-inch valves needed. Potato storage operators wishing to install a flume system should investigate the prices for component parts and select a system which gives the lowest cost installation and meets performance requirements. Also, in determining costs, they should consider the local power rates. It also might be advisable to evaluate the different systems by assuming a 25-year life, interest at 6 percent a year, and repairs and maintenance at 1 percent a year.

The figures in tables 5 and 6 are given to assist the pump buyer to decide on the size of piping he needs and wants. However, any reputable pump dealer, who is familiar with these problems, should be relied upon to advise on motor and pipe sizes.

TABLE 4.--Friction head loss for 200 feet of 3- to 6-inch iron or aluminum pipe including couplings, through 90° turns and one valve, when carrying 200 to 600 gallons of water per minute[1]

Water carried	Friction head for pipes, couplings, and fittings when nominal pipe sizes are[2]:			
	3 inches	4 inches	5 inches	6 inches
	Feet	*Feet*	*Feet*	*Feet*
200 g.p.m.	36	8	2	1
300 g.p.m.	72	17	5	2
400 g.p.m.	--	30	10	4
500 g.p.m.	--	46	15	6
600 g.p.m.	--	--	21	9

[1] Friction head losses for iron pipe were computed by using the formula developed by Box and for aluminum irrigation pipe by using the formula developed by Gray, Levine, and Bogema.

[2] Inside diameter of standard steel and aluminum irrigation pipe in inches when nominal size of pipe is:

	3 inches	4 inches	5 inches	6 inches
Standard steel	3.068	4.026	5.047	6.065
Aluminum irrigation	2.90	3.90	4.896	5.876

TABLE 5.--Friction and static head and motor size required to deliver 300 gallons of water per minute through a maximum of 150 feet of pipe of different sizes at the Red River Valley Potato Research Center

Factor	Pipe size in inches			
	3	4	5	6
Friction head caused by pipes and couplings, through 90° turns and one valve..........feet.......	54	13	4	2
Static head at sump...........feet.......	10	10	10	10
Maximum head..................feet.......	64	23	14	12
Average head--300 hours per season.......................feet.......	37	17	12	11
Motor size required...........horsepower.	12.5	5	3	3
Average power required--300 hours per season............horsepower.	6.7	2.7	2.4	2.2

TABLE 6.--Costs of ownership and operation of motor, pump, aluminum pipe, and fittings for a flume system to deliver 300 gallons per minute through a maximum of 150 feet of pipe at the Red River Valley Potato Research Center

Pipe size	Cost of 150 feet of pipe and fittings	Cost of 4-inch pump and motor of proper size[1]	Annual ownership costs[2]	Power cost for operating flume system[3]	Total
	Dollars	*Dollars*	*Dollars*	*Dollars*	*Dollars*
3 inches..........	248	768	101.60	60.00	161.60
4 inches..........	294	644	93.80	26.40	120.20
5 inches..........	351	606	95.70	21.50	116.20
6 inches..........	429	606	103.50	19.75	123.25

[1] See table 5 for size of motor required.

[2] Based on 10 percent of pipes, fittings, pump, and motor. Costs of flumes are not included.

[3] Power costs were computed at a rate of 4 cents per kilowatt hour.

Valves

The method that uses irrigation pipe to bring water to the front of the bin needs fewer valves than the method that brings water into the rear of the bin. However, even in the latter method the number of costly valves can be reduced by substituting caps for the valves and shutting down the pump while changing from one bin to another. The extra cost of a walkway for access to valves or caps at the rear of the bins may be avoided by running valved lines from the alley to the back of each bin.

Sump

The sump is actually a water reservoir, and the area around it serves as the control area for the fluming system. Here, the equipment for removing potatoes from the flume, as well as the pump and valves to control the volume of water in the flume and to remove the sludge, is located. Also, waste water from the washer and sludge and trash collect here. An overflow at the sump prevents water from backing up into the flumes.

Figure 8 shows a pump layout. The arrangement of valves must fit the fluming and sludge line levels. A 3-inch pipe is usually adequate for sludge disposal.

The sump should be large enough to hold the water required to fill all flumes and pipes, plus sludge accumulated between cleanouts. Instead of using an overflow to dispose of excess water running into the flume system from the washer, some operators set the valves so that an equal volume of sludge-bearing water is pumped from the bottom of the sump. This procedure removes the sludge and keeps the sump nearly free of sludge at all times. Other operators drain the relatively clean overflow into the sewer and intermittently remove the sludge. A sump should hold 1 cubic foot of water for each foot of flume.

Drainage and Sludge Disposal

Generally, disposal of unsettled sludge in public sewer systems is not recommended. However, if trash, such as vines and roots, is ground in a hammer mill, some municipalities may permit the trash to be put into the public sewer with adequate flush water. A more common practice is to pump the sludge from the flume onto an adjoining disposal field. Ordinarily, it will be necessary to construct a dike about 3 feet high around this field.

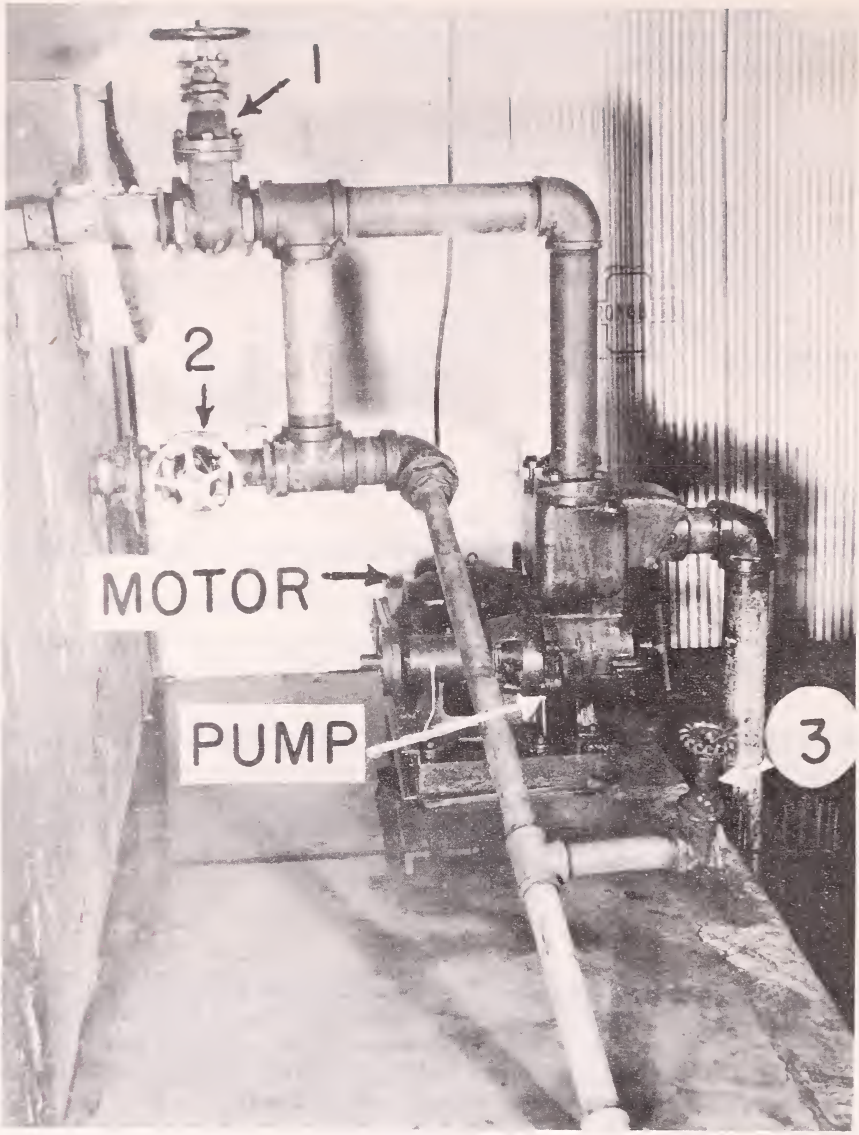

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Figure 8.--Pump, motor, and valves installed at sump. When upper valve (1) is open and valve (2) is closed, water is delivered to flume system; when center valve (2) is open and (1) closed, sludge is pumped to disposal field; and when center valve (2) and lower valve (3) are open and pump stopped, sludge is drained back to sump to prevent freezing at outlet.

The field should cover about 2,000 square feet of space per carload of potatoes washed per day. During the shipping season, excess water will usually seep down into the soil. This happens even during the severe Red River Valley winter weather.

Local ground water, public sewer facilities, and local sanitary regulations should always be checked before the method to be used for sludge disposal is decided on.

FLUMING CYCLE

The following are the steps in the fluming cycle:

1. The sump is filled to the overflow.
2. A 300 to 600 g.p.m. pump forces water through 4-inch to 6-inch pipe to (a) the end of a flume at the back of the bin to be emptied or (b) to a 6- to 8-inch hose to wash potatoes from the front of the pile into the flume.
3. Potatoes roll onto the floor and into the flume, assisted either by hand or by water.
4. Potatoes, at a ratio of about 8 pounds of potatoes to 10 gallons of water, are washed down the flume to a draper chain conveyor or hopper at the sump.
5. Water flows through the draper chain or out of the hopper, and potatoes move to the packing line.
6. Twenty to eighty g.p.m. of water from the washer keep the sump at the overflow level; relatively clear excess water drains to the sewer.
7. Sludge and trash accumulate in the sump during fluming. Trash that does not pass the grating over the pump intake is removed by hand or is broken up in hammer mill and disposed of.
8. Between packing runs sludge is pumped to a disposal field. Sludge is first diluted with fresh water at line pressure, which also serves to break up the sediment that becomes packed on the sump floor.

COSTS OF EQUIPMENT, INSTALLATION, AND OPERATION

The costs of equipment, installation, and operation of the fluming system at the Red River Valley Potato Research Center are summarized as follows:

Equipment and installation costs:		
300 g.p.m. 4-inch pump and 5 hp. motor	$644.00	
150 feet of 4-inch aluminum irrigation pipe, 3 90° turns, 1 tee, and 2 valves	294.00	
450 feet concrete flume at $3 per foot	1,350.00	
Sump and waste line to disposal field	300.00	
Total equipment and installation costs		$2,588.00
Annual operating costs:		
Investment cost (10% of $2,588)	$258.80	
Power (300 hrs. operation at 2.7 hp. = 605 kw.-hr. at 4¢)	24.20	
Labor (300 man-hrs. at $1 per hr.)	300.00	
Cleanout water (fluming water recirculated)	20.00	
Total operating costs		603.00

On the basis of this analysis, costs for fluming the equivalent of 60 carloads of potatoes a year from the deep bins to the packing line are about $10 a car or 1.5 cents a bushel.

The development of detailed costs for comparing the fluming of potatoes with other handling methods is beyond the scope of this publication. However, four major items of cost--labor, equipment, maintenance, and power--when considered together, favor fluming over any other known bulk-handling method used to move potatoes from storage to the washing and packing line. This may not be true where distances are relatively short.

Labor required for fluming is generally one-half of that required for other methods or less. One man, feeding potatoes into a flume system, can provide potatoes to the packing line for 6 cars a day almost as easily as for 1 car a day.

When considering equipment costs alone, conveyors will probably be cheaper than flumes up to about 100 feet, because the cost of sump, pump, and allied equipment would be about the same as for that length of suitable conveyor. Beyond that distance the cost of flume and pipe at about $5 a foot has a distinct advantage over conveyor cost of about $20 a foot.

Maintenance cost assignable to fluming involves only pump and piping. The flume and sump normally require no maintenance. This cost compares favorably with costs incurred with other mechanical handling methods.

Power cost for fluming also compares favorably with power costs for conveyors for distances of 100 feet and over.

A further item of cost, removing soil from the storage, should be considered. At the Potato Research Center approximately 22 tons of soil, brought from the field with 1,000 tons of potatoes, cost $500 to remove by conventional hand methods. This cost was reduced to $30 when accumulated soil was pumped from the sump to an adjacent disposal field. This amount of soil will build up at the rate of about 3/4 inch per year when evenly distributed on a 100-foot by 100-foot disposal field.

CONCLUSIONS

Overall layout and proper slope of floors and flumes are of major importance to the satisfactory operation of a flume system. It is desirable, but not necessary, that the floors slope to the flume. In new construction it is possible to reduce form costs by sloping the floor with the flume on long straight runs. This results in flumes of uniform depth and top width and permits shallower flume forms of identical shape and size.

Sandbag dams can be used in storages with level floors to confine potatoes and water to a given area and funnel them across the floor into the flumes. These dams can be mildew-proof canvas bags, 6 inches in diameter, loosely filled with sand. Four- to six-foot lengths can be conveniently handled.

Fluming requires less labor and handles potatoes with less injury than do conveyors, and ownership and operating costs are less for the longer distances. In addition, it presoaks the potatoes and thus loosens the soil before the washing operation. For these reasons fluming should be carefully considered for moving potatoes from bulk bins to stationary washing and grading lines.

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